

# Nearshore Placement: Engineering Considerations to Optimize Benefits

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# Regional Sediment Management Approach

## RSM Program

Regional Approaches    Coordination    Technology Data Gaps

*Integrate Across Projects and Authorities*

**Navigation  
O&M**

Continuing  
Authorities  
Program

Dredge  
Material  
Mgmt Plans

Feasibility  
Studies

Other

## Construction



## U.S. Army Corps of Engineer Projects at St. Johns County, Florida, U.S.



## RSM Operating Principles

- Recognize sediment as a regional resource – connect beaches & inlets
- Evaluate use of all sediment sources & sinks
- Optimize operational efficiencies & natural exchange of sediments
- Balanced, economically viable, environmentally sustainable solutions
- Improve economic performance by linking multiple interacting projects
- Consider regional impacts
- Adaptively manage

# Why Nearshore Berms?

- **Sand is a Resource:** Sand is a valuable resource. Every effort should be made to retain it to the nearshore.
- **Nearshore Berms may provide** - a supplementary route in addition to beach nourishment.
- **New numerical modeling methods and field data** - including CMS and LIDAR provide new tools for design analysis

OFFSHORE

$d_{outer}$  = the closure depth of the shoal/buffer zone

$d_{inner}$  = the closure depth of the littoral zone

0%



100%



# In the context of Regional Programs and Scales, what are the Engineering Considerations for Nearshore Berm Design?

- Tides
- Waves
- Currents
- Sediment Types



# Engineering with Nature: Given what we do know about the character of the nearshore, how do we optimize placement to retain sediment to the littoral zone?

- Tides
- Waves
- Currents
- Sediment Types



In a nutshell . . .



. . . Sediment Transport is:

*What goes up . . .  
Must come down . . .*

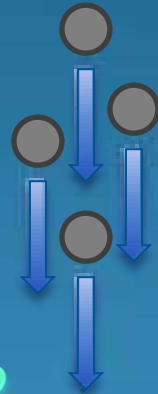
*That's pretty easy.*

*. . . It's just the "where" and "when" that's the tough part.*





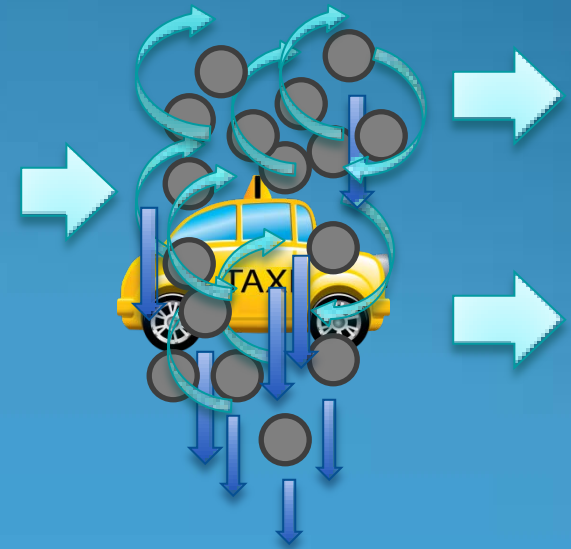
Fall Velocity = DOWN



Turbulence = UP



Currents = Transport



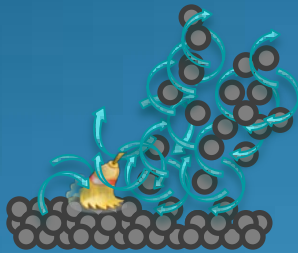


# Sediment Transport is Described by the Advection Diffusion Equation

## *DIFFUSION*



Turbulence = UP



Bed Stress

- Currents
- Waves

*Sweeps the sediment up  
into the water column*

*VELOCITIES*



Fall Velocity = DOWN



Gravity

- Sediment Size/  
Shape
  - Sediment Density
- Brings sediment to  
the bed*

*SEDIMENT*

## *ADVECTION*



Currents = Transport



Currents

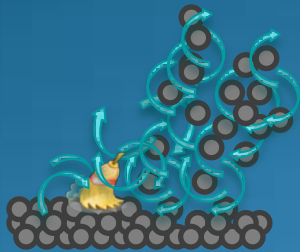
- Upwelling/  
Downwelling
  - Wind
- Surf Zone  
Currents
  - Waves

*FLOW*

# What do I need to know?



Turbulence = UP



Currents = Transport



Fall Velocity = DOWN



Turbulence

- Wave orbital velocities
- Current velocities
- Broken Waves



• Sediment characteristics



• Surf zone currents

- Broken Waves
- Undertow
- Alongshore Currents

- WAVES
- CURRENTS

- SEDIMENT

- SURF ZONE HYDRODYNAMICS

# Nearshore Waves

- Waves are important because they provide:
  - Turbulence – Pick Up Sediments at the Bed
  - Wave Refraction – Longshore Currents
  - Wave Breaking – Cross-Shore Currents

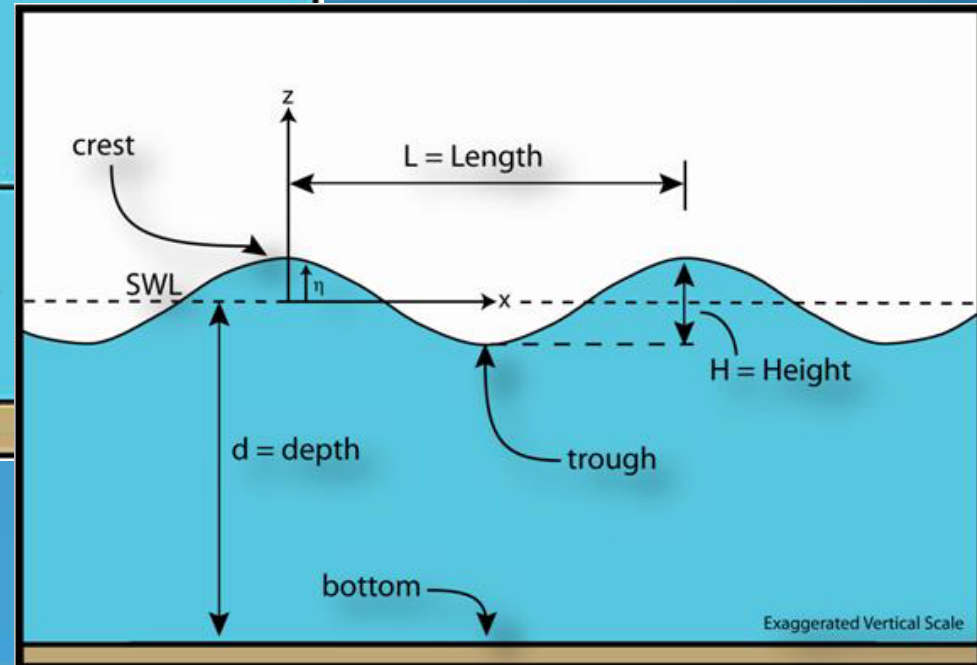
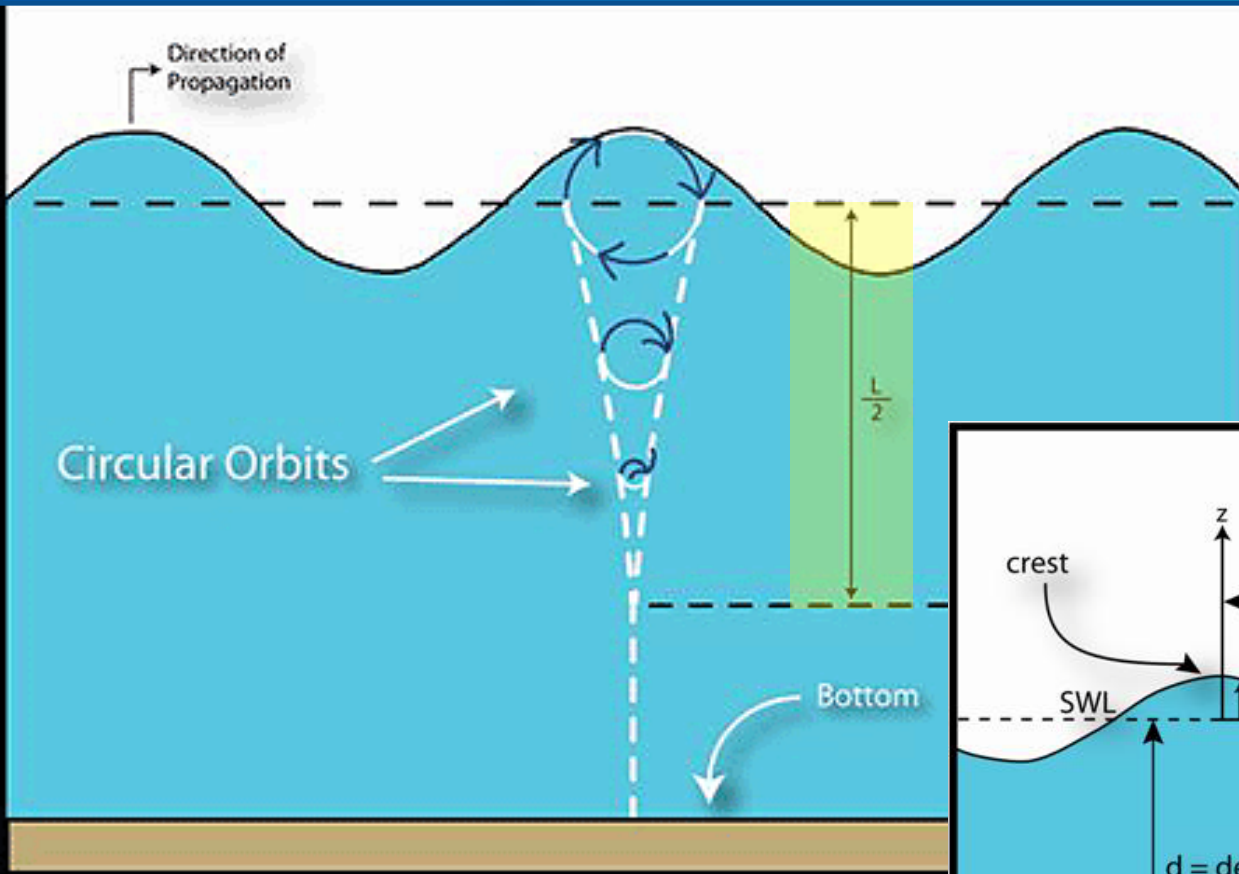


# Deep Water Waves – No Pick-Up

OFFSHORE



ONSHORE





# Wave Shoaling

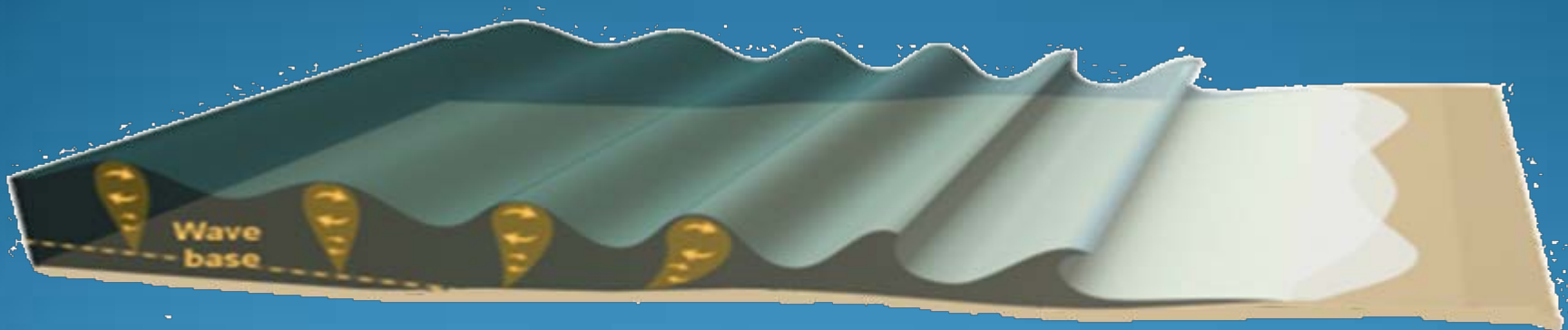


OFFSHORE



ONSHORE

*... as waves move onshore:*



- Friction @ BED
- $\Delta$  Wave Shape

# Wave Refraction

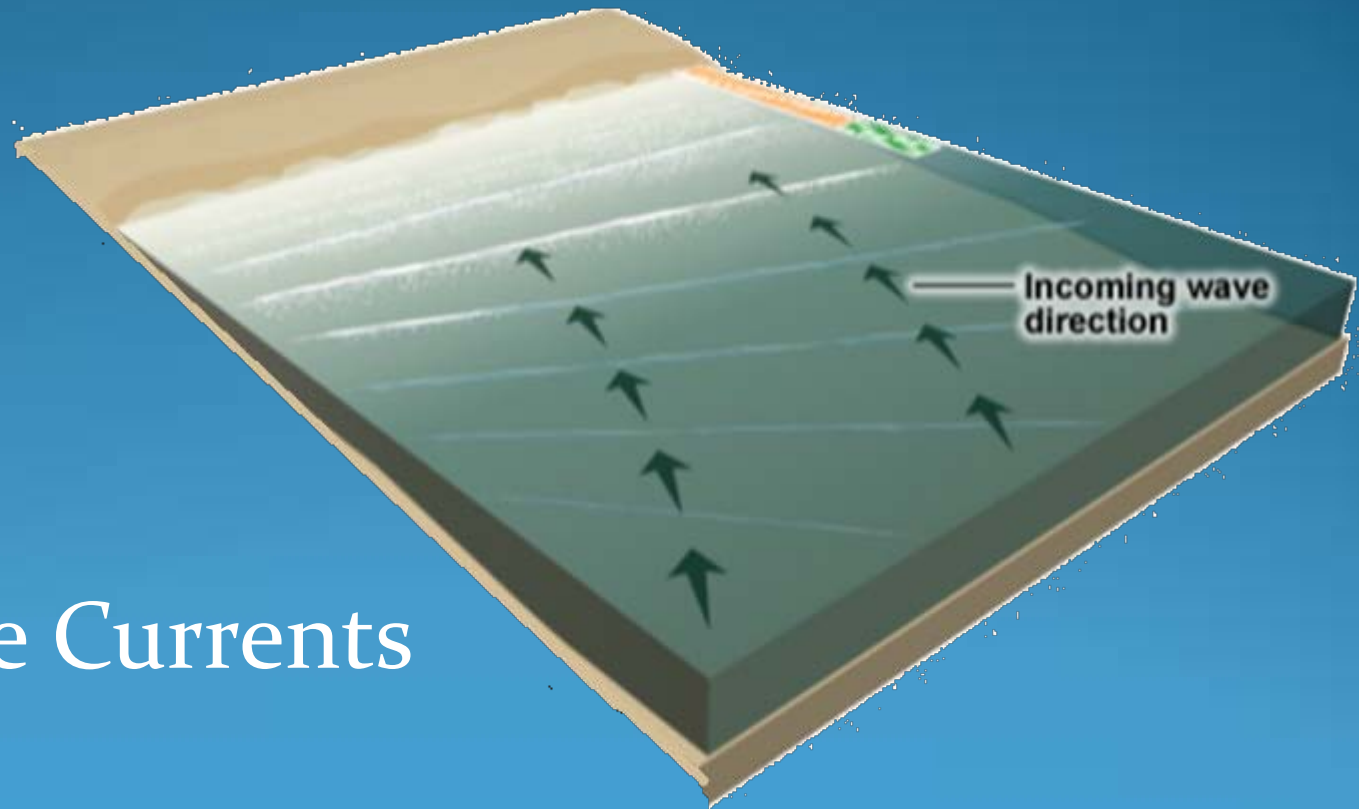


OFFSHORE



ONSHORE

*... as waves move onshore:*



- Alongshore Currents

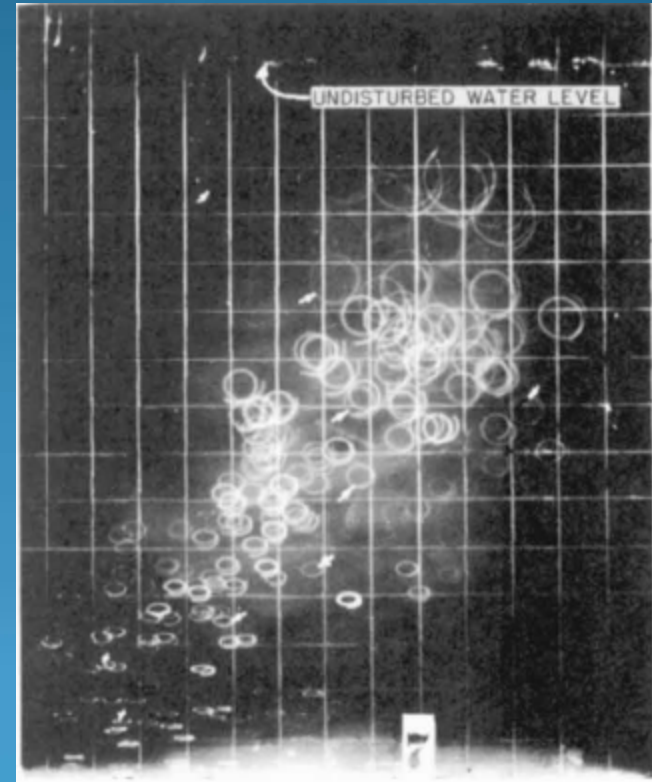
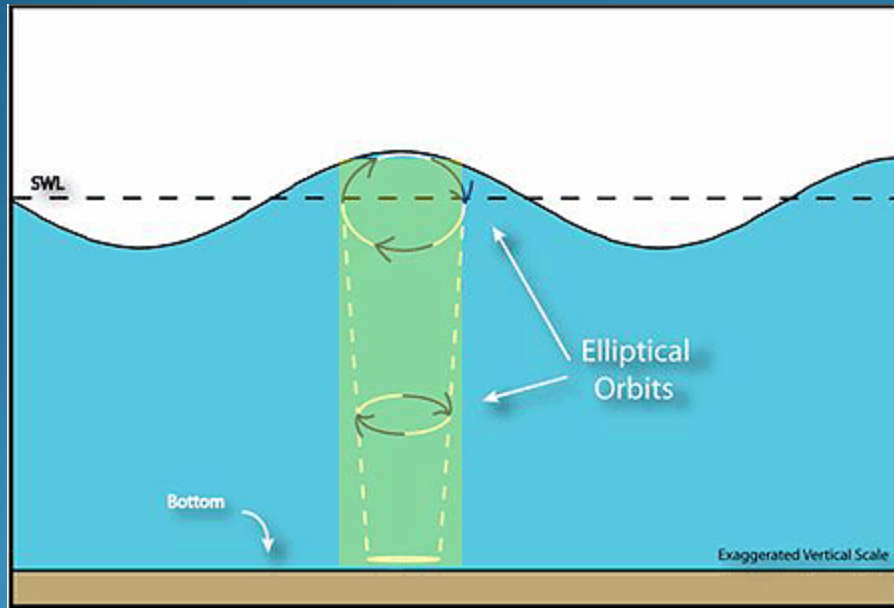
# Shallow Water Waves – Pick Up



OFFSHORE



ONSHORE



# Wave Breaking



OFFSHORE



ONSHORE

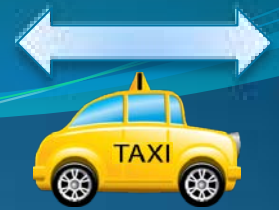
Wave Breaking = Turbulence and Transport

- Breakers pick up large amounts of sediment and transport landward





# Wave Run-Up - Undertow



OFFSHORE



ONSHORE

- From the Breakers



- Shoreline interrupts flow – returns as undertow



# Putting it all together on the Beach



**Turbulence = UP**



**Turbulence**

- *Wave orbital velocities*
- *Current velocities*
- *Broken Waves*



**Fall Velocity = DOWN**

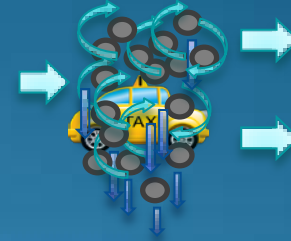


**Gravity**

- *Sediment characteristics*



**Currents = Transport**



**Currents**

- *Surf zone currents*
  - *Broken Waves*
  - *Undertow*
  - *Alongshore Currents*

How do these forces influence beach profile evolution?

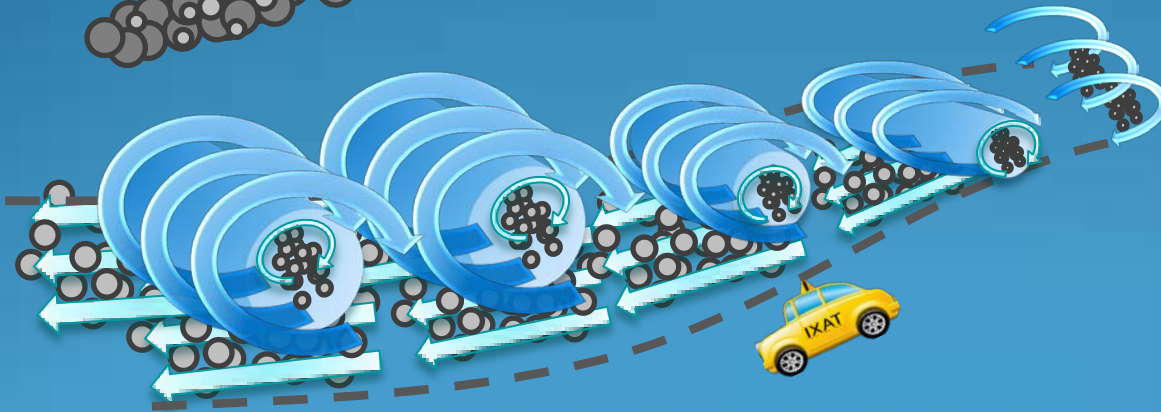
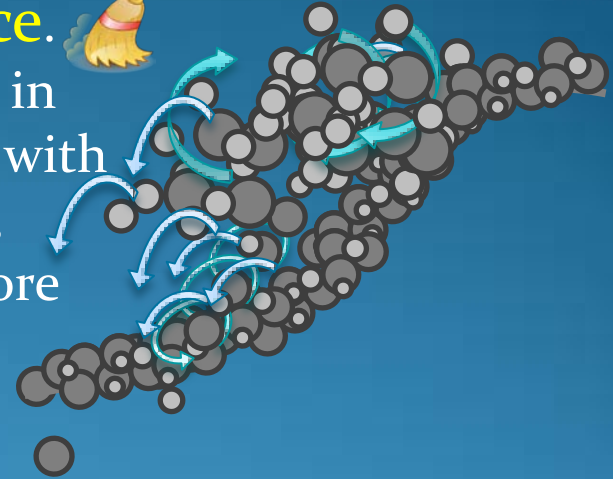
# Destructive Forces that move sediment offshore

... an incomplete list

- **Gravity.** Tries to make a profile horizontal



- **High Turbulence.** Picks up sediment in the surf zone and, with the help of gravity, moves them offshore



- **Undertow.** Seaward return of wave-induced mass transport (surface roller)

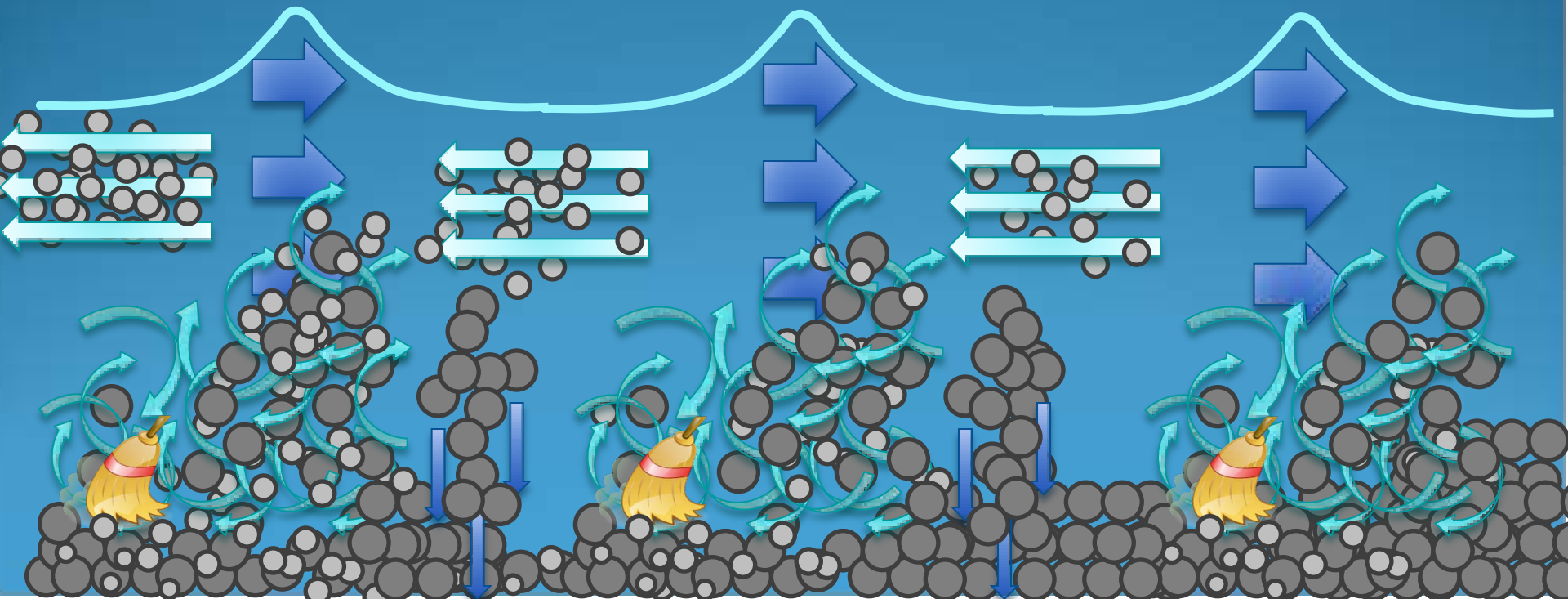


# Constructive Forces that move sediment onshore

... *an incomplete list*

- SHALLOW WATER WAVES

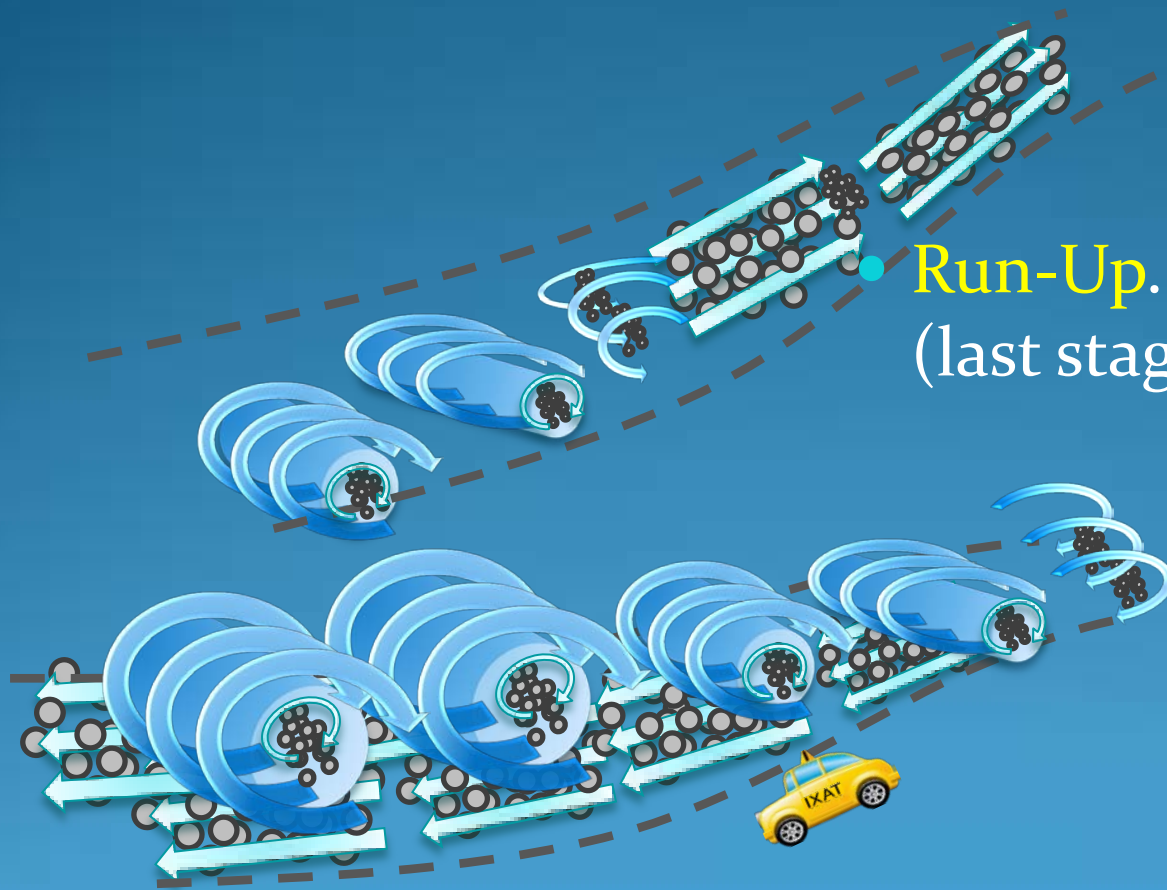
- Strong Velocity under the Crest sweeps coarse grains shoreward. Weak velocities under Trough keep fines in suspension and they move offshore in the longer duration trough. *A means of natural sorting.*





# Constructive Forces that move sediment offshore

... an incomplete list



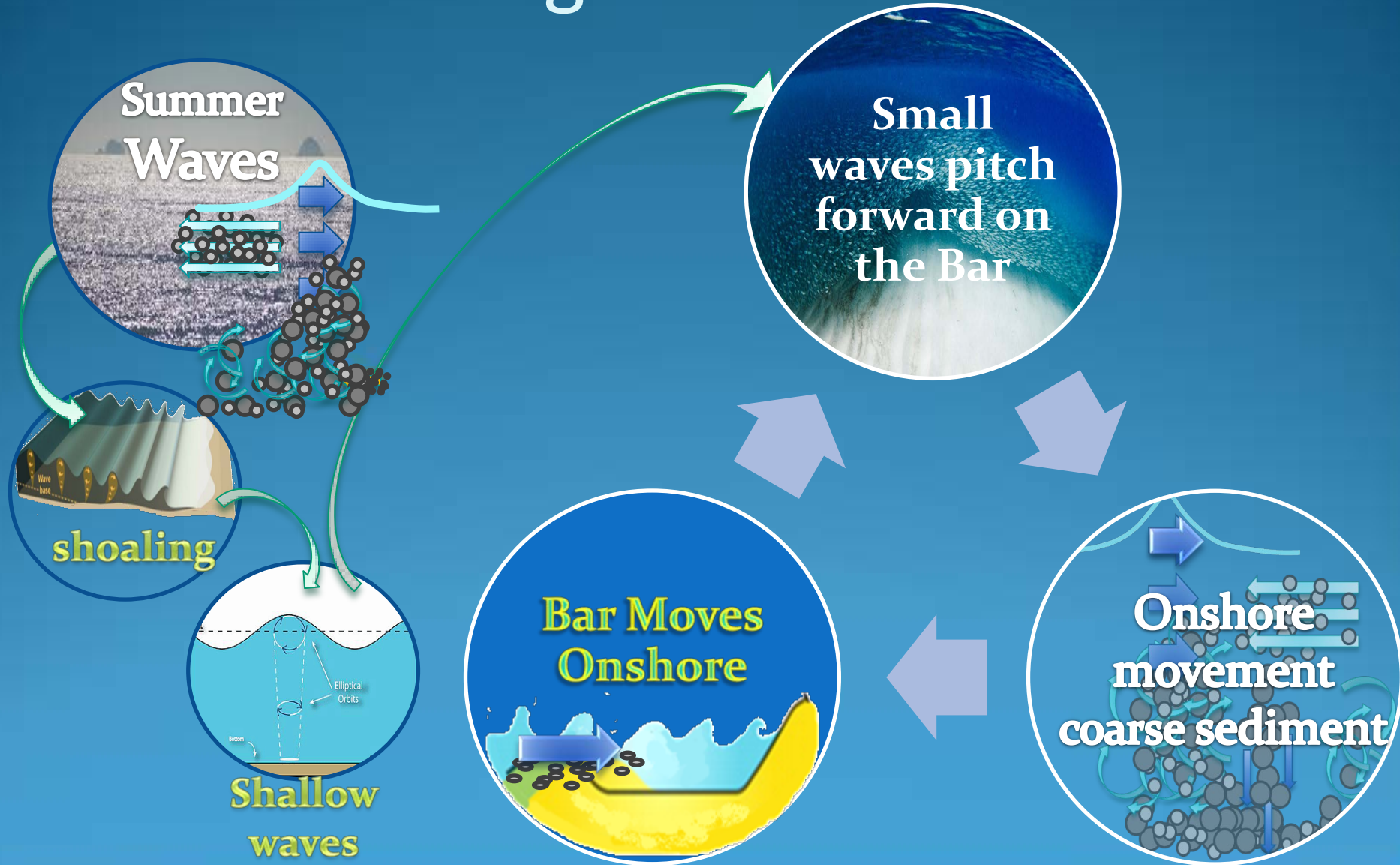
• **Run-Up.** Shoreward transport (last stage of wave dissipation)

• **Wave Bore.** Shoreward wave-induced mass transport (surface roller)

# Mimicking Nature: *Destructive* Forces and migration of sand bars

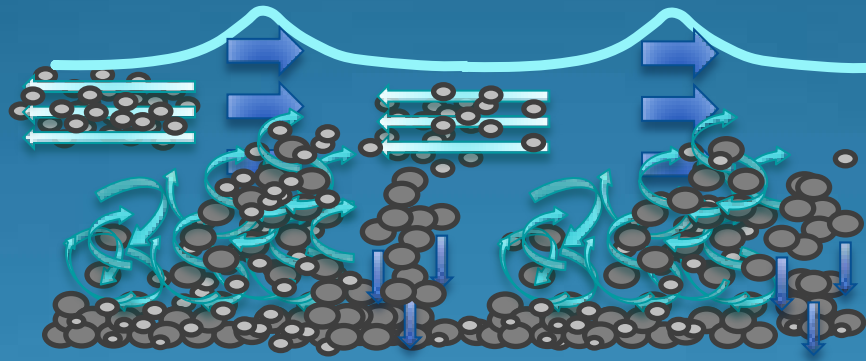


# Mimicking Nature: *Constructive* Forces and migration of sand bars





# Engineering with Nature: Create a nearshore berm that behaves similarly to a summer bar – Shallow Waves.



*fn*=  
**WAVES,**  
**sediment**

Hallermeier Depth of Closure 1981,1983:

$d_{\text{inner}} (H^2, T^2), d_{\text{outer}} (H, T, d_{50})$

$d_{\text{outer}}$  waves and sediment characteristics

$d_{\text{inner}}$  wave climate, alone

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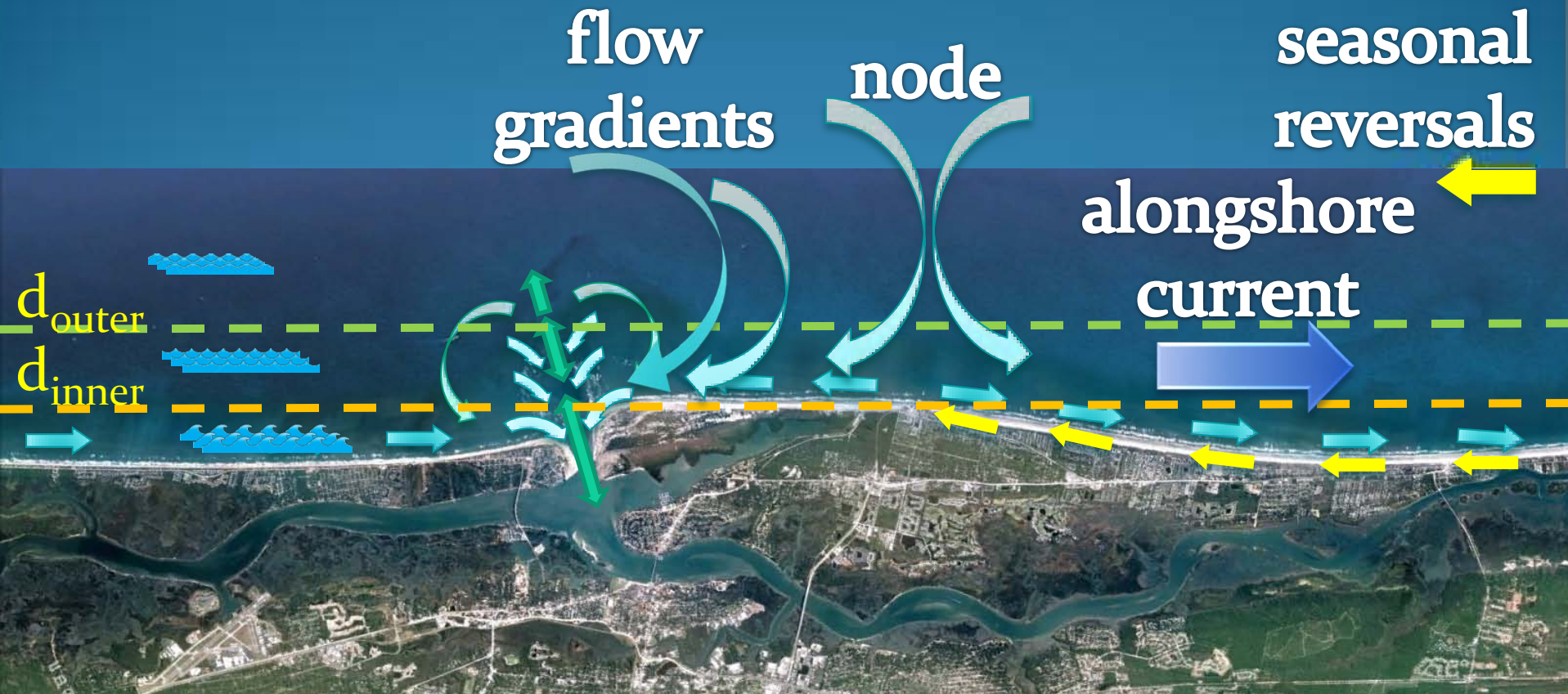


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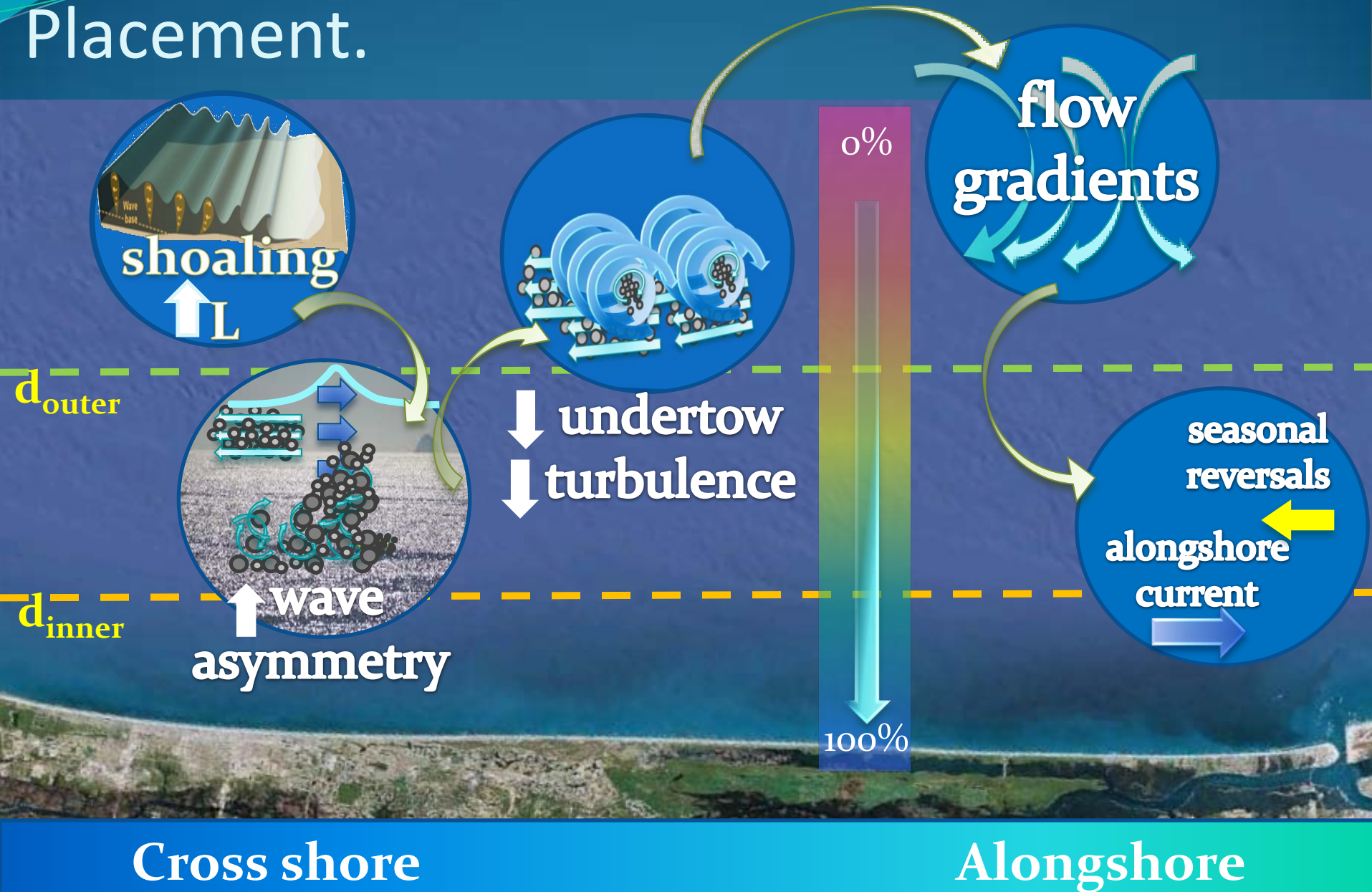




# Engineering with Nature: Large Scale Alongshore Advection and Diffusion.



# Engineering with Nature: Optimizing Placement.



# Why Nearshore Berms?

- **Sand is a Resource:** Sand is a valuable resource. *We find a good surrogate in nature, nearshore bars, about which we have a good understanding.*
- **Nearshore Berms may provide** - a supplementary route in addition to beach nourishment which will retain sediment to the littoral zone
- **New numerical modeling methods and field data** - including CMS and LIDAR provide new tools for design analysis. CSHORE and GENESIS coming online as well.
- **Given the wealth of existing knowledge on cross-shore transport and predictive tools, we are in an excellent position to consider nearshore berms as an additional option for sediment placement.**

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100%

